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FEBRUARY 1, 1988
CHEMICAL & ENGINEERING
NEWS

PRELIMINARY PROGRAM
3rd Chemical Congress of
North America, Toronto Page 33

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High-Tech Ceramics

Composites promise toughness for structural applications
Page 7

CHEMICAL & ENGINEERING
NEWS

Volume 66, Number 5
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FEBRUARY 1, 1988

News of the Week

■ **Sterling Drug accepts Eastman Kodak's $5.1 billion acquisition offer following aggressive bids by Hoffmann-LaRoche.** **Page 4**

■ **New class of high-temperature superconductors that consist of relatively common, inexpensive elements could make future large-scale superconductivity applications more economical.** **Page 5**

■ **All-protein, low-calorie fat substitute has been developed by NutraSweet Co., which plans to have the product ready to market in 12 to 18 months.** **Page 5**

■ **Tests to identify alcoholics and people predisposed to alcoholism may result from discovery of certain biochemical markers.** **Page 6**

■ **Alaska's North Shore is suffering alarming environmental problems as a result of oil and gas drilling, say the Natural Resources Defense Council and the National Wildlife Federation.** **Page 6**

Cover: 3M technologist uses propane torch to show heat resistance of strands of 3M's Nextel ceramic fiber, which can be added to ceramics to make tough composites

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Preliminary Program

Preliminary program of 3rd Chemical Congress of North America and 195th ACS national meeting, to be held jointly in Toronto, includes list of symposia and advance registration coupon. **Page 33**

News Focus

High-tech ceramic composites, produced by incorporating ceramic fibers, whiskers, and particulates into ceramic matrices, have improved properties such as fracture resistance, strength, and high-temperature stability. **Page 7**

Chemical & Engineering News

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LETTERS

CHEMICAL SAFETY

Alkyl(thio)ethyl sulfides

SIR: A number of alkyl(thio)ethyl chloride ($RSCH_2CH_2Cl$) derivatives are commercially available and frequently synthesized in laboratories for use as radioprotective chemicals and for kinetic studies as model compounds. With gas chromatography/mass spectroscopy we detected trace amounts (0.05–0.1 mole %) of the chemical agent mustard $[S(CH_2CH_2Cl)_2]$ as a degradation product in the aged samples of methyl, ethyl, and phenyl derivatives. As high as 6 mole % mustard was found in the benzyl derivative, which decomposes more readily. All of the above compounds were acquired commercially and stored at ambient conditions for about one year. We would like to alert the chemical community of the increased toxicity of these compounds as they age.

The degradation process is believed to be initiated by the intramolecular, nucleophilic assistance of sulfur in the leaving of chlorine to form a reactive cyclic ethylene sulfonium ion, which is then quickly trapped by another molecule of the sulfide to form a relatively stable dimeric sulfonium chloride $[RS^+(CH_2CH_2Cl)(CH_2CH_2SR)Cl^-]$. With time, this compound slowly transforms to a number of secondary cations through further nucleophilic substitution reactions at the three electron-deficient carbon atoms adjacent to the S^+. This includes the formation of the $RS^+(CH_2CH_2Cl)_2$ cation, which decomposes to mustard (and RCl) as detected by GC/MS.

Mustard is a vesicant and can be contaminated by oxidation with bleach or peroxide solutions.

Yu-Chu Yang
Dennis K. Rohrbaugh
J. Richard Ward
U.S. Army Chemical Research Development & Engineering Center
Aberdeen Proving Ground, Md.

Shock-sensitive salt

SIR: Dow Chemical Co. has found that the water-insoluble salt formed from mixing aqueous solutions of the polymerization initiators sodium persulfate and 2,2′-azobis (2-amidinopropane) hydrochloride is shock sensitive. The degree of shock sensitivity varies with moisture content, being greater at lower moisture levels, and is similar to that of lead azide.

Extreme measures should be taken to prevent aqueous solutions of these commercially available polymerization initiators from coming into contact with each other external to the polymerization environment.

D. A. Rausch
Corporate Safety and Loss Prevention
Dow Chemical

Chemical engineering

SIR: I have comments regarding two items in the Nov. 30, 1987, issue of C&EN.

First, the major article summarizing the National Research Council's report on chemical engineering's frontiers is very timely in at least two respects. One deals with the opportunities for persons with a chemical engineering background in materials science and engineering. It has been evident to me for some time that chemical engineers are perhaps even better qualified for materials processing research, development, and production roles than the typical materials engineer. That advantage is due to the generally higher level of computational skills possessed by most chemical engineers. It is quite apparent that materials science and engineering is headed for a more computational future. For example, the work done by people like professors Szekely at Massachusetts Institute of Technology and Brimacombe at British Columbia on process simulation is worth noting. If only the chemical engineers had a bit more experience in mechanical behavior.

The other timely feature of the article on chemical engineers is their likely pivotal role in resource and waste management. Their technical qualifications are clearly suited to the problems of analytical measurement and process control that underlie existing and developing practices in these technologies. However, I'm not sure that they will have been exposed to the philosophies that distinguish between short-term and long-term solutions to such problems: e.g., the considerations presented by Hirschhorn (*Pollution Engineering*, November 1987, page 62).

The second item of the Nov. 30 issue

Strong Demand for Polypropylene Spurs Expansion Plans

Global growth of 10% over past decade has pushed plants to limit; producers see brief excess capacity in 1990–91 but still high operating rates

Patricia L. Layman, C&EN London

With plants running at nearly 100% of effective capacity, and sometimes more, polypropylene producers around the world—and some companies not yet in the business—are building or making plans to build new production facilities. They have decided to up their stake in a "specialty shop" business characterized by many grades and types of polymer, and many different end uses.

Two central questions are raised by those decisions. Is the polypropylene industry embarking on a lemminglike course of collective madness, with gross overcapacity on the horizon? Or are corporate managers actually making wise decisions in building now for present and anticipated growth?

Naturally enough, producers are convinced that their plans are justified by the strength and growth of polypropylene markets. Yes, they say, there will be a brief period of overcapacity in about 1990 or 1991, when a large part of the new capacity goes on stream, and operating rates will dip down into the 85 to 90% range. But that's a far cry, they add, from the low points experienced in the years between 1978 and 1982, when operating rates dipped near 60%, never rising much above 75%.

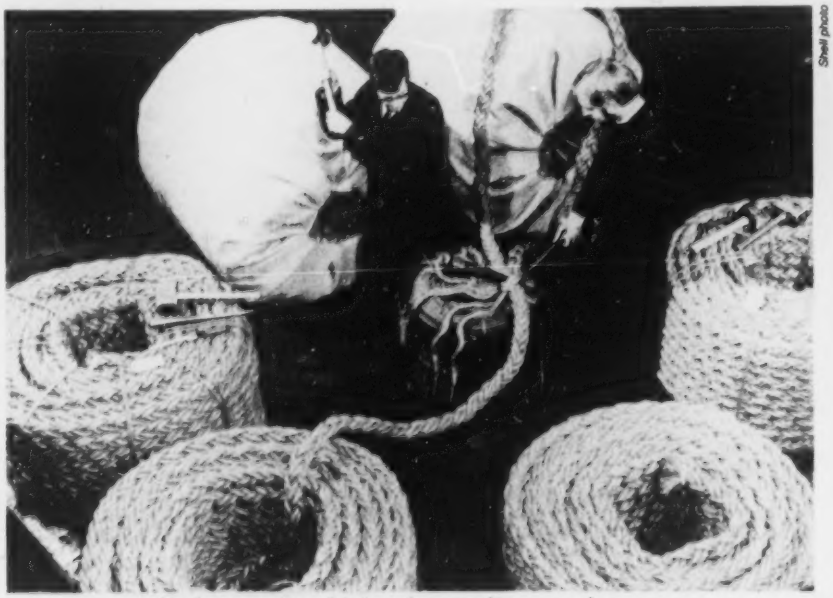
On the other hand, industry analysts have their reservations. Some see definite "lemming" signs. Others see grounds for caution, but overall, they believe, polypropylene producers may be justified in their expansionary plans.

Key to those plans are the impressive growth rates registered by polypropylene over the past decade. West German producer Hoechst calculates that worldwide demand from 1976 to 1986 grew an average 10.6%. Dutch producer DSM pegs global polypropylene demand growth between 1982 and 1987 at 8% per year. For Western Europe, in particular, growth has been even better: 11.4% per year between 1976 and 1986, according to Hoechst—more than double growth in demand for high-density polyethylene at 5.1%.

According to Gerald W. Pearson, vice president for plastics for Dow Chemical, speaking at a European Chemical Marketing Research Association (ECMRA) meeting in Barcelona last November, by 1995 polypropylene will account for 17% of global plastics consumption of 76 million metric tons. That share is up from 15% of 52 million metric tons in 1985.

With that kind of growth, marketers say, it is no wonder producers are busy working on expansion plans, because capacity increases have not kept pace with growth. In 1987, production, which had been edging up toward plant capacities, actually overtook capacity. As a result, marketers have been scrambling to supply customers, and, in turn, customers have been whittling down stocks. As one producer puts it, "All the plants are stretched out like elastic bands."

In some respects, polypropylene is just catching up with the other major polymers. With growth coming both from increasing consumption in present applications and in new substitutions, the real innovative potential for polypropylene was discovered relatively recently, considering how old the product is (the



Shell photo

Workmen splice ship's polypropylene mooring rope

Himont dominates technology and industry

Currently, the polypropylene industry is dominated by Himont, formed in 1983 as a joint venture between Hercules and Montedison, and now owned 80% by Montedison and 20% publicly held. The venture joined Hercules' strong marketing organization and Montedison's technological and production expertise. It also yielded an operation that now accounts for nearly one fifth the world's polypropylene production.

Himont also has embarked on an aggressive campaign to license its technology, originally developed by Montedison and Mitsui in Japan but considerably broadened and improved by Himont. The company licensed 16 customers in 1987; its licensees currently account for roughly 50% of world capacity.

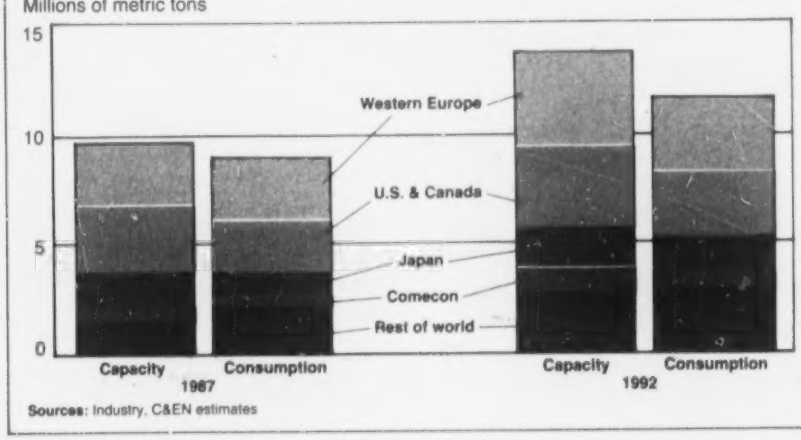
Probably the next most widely based technology is BASF's. Its technology will account for about 10% of world capacity currently in place and being installed between now and 1992. BASF's position was boosted by the formation of a tripartite agreement in October 1987 between it, ICI, and National Distillers & Chemical (now Quantum Chemical) in the U.S. to cooperate on research and development and to share process improvements.

Other major processes for license include the "super high activity" process of Shell in the U.K. and the U.S. Shell has linked up with Union Carbide in a process derived from Carbide's Unipol process for polyethylene. El Paso Products in Bayport, Tex., licenses Carbide's process; Solvay in Belgium has its own process; and DSM in the Netherlands has yet another. Virtually all companies are working on catalyst systems, building on the new generations that have developed. Neste, for example, soon will start up a pilot plant in Finland based on its own know-how, to help work on its own technology.

All the new technologies feature what Chem Systems consultant David F. Oxley terms "third-generation, high-yield catalysts," and his predictions as to future growth and capacities assume that by 1995 most producers will have them—if not the fourth-generation catalysts claimed by Himont. First-generation catalysts yielded about 1000 kg of polymer per kg of catalyst. Yields were boosted to 5000 to 10,000 kg per kg with second-generation formulations and about 30,000 kg per kg with fourth-generation catalysts.

Catalyst technology is based on formulations of titanium supported on magnesium halide, an organometallic component, and a Lewis base as the electron donor. Each of them, in the variety of technologies, whether liquid slurry, gas phase, or liquid bulk, or modifications or combinations, will give roughly similar processing costs, Oxley believes. "The cost of polypropylene then will basically be the cost of propylene," he says.

Western Europe to lead global polypropylene growth



Sources: Industry, C&EN estimates

original patents date back to the early 1950s). The innovations have come both in replacing natural materials, such as raffia and jute fibers, and metals, woods, and paper, and in replacing other polymers, particularly those more expensive than polypropylene, such as polyamides and acrylonitrile-butadiene-styrene.

Some of the replacement of other polymers has been in fibers—polyester, in the raffia sector, for example. But the big opportunities really came with the advent of the Arab oil crisis, when the need for materials that could reduce vehicle weight to cut fuel consumption became crucial.

After autos, other markets began opening up to polypropylene. Thermoforming of food packaging—yogurt and margarine cups, for example—has become a major market for the polymer. Other packaging applications are important for polypropylene film. Uses in textiles—in disposable nonwovens, for instance, and in industrial fabrics—also have increased. Growth has been for the sake of its intrinsic qualities, and also for substitutions.

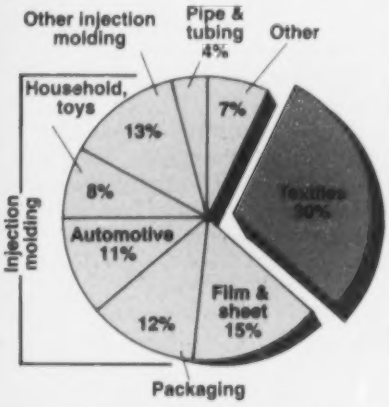
It's the continuing substitutions and diversity of markets that encourage marketers preparing their forecasts. "Look at polyvinyl chloride," says one supplier, "70% of it goes into construction. Most acrylonitrile goes into acrylic fibers. Polypropylene has all sorts of various uses." That factor, the supplier believes, helps shield polypropylene from the vagaries of economic ups and downs.

Additionally, "The growth rate in double digits over the past years has been because substitution has gone up tremendously. The price of polyolefins has gone down, so that now, polypropylene is a cheap product in the technical sense—the ratio of price to performance is very good, so people try to substitute it for other materials where they can."

Other growth is coming from developing countries. Says one marketer, "Polypropylene goes very well with developing countries, and as their standard of living increases, consumption of polypropylene will increase."

China, with its huge population, is one of the largest potential mar-

Textiles are largest single use in Europe



Total 1987 polypropylene demand = 2.63 million metric tons

Sources: Industry, C&EN estimates

kets. As with so many other things, polypropylene consumption—if increased by only a little bit per capita—could increase tremendously in total consumption, suppliers point out. China itself has a number of plans for polypropylene, as do other countries in the Far East. But U.S. and Western European producers feel that those regions will remain net importers well into the next decade. In Barcelona, Dow's Pearson told the ECMRA, for example, that by 1995, China would still be importing 390,000 metric tons per year of polypropylene.

Naturally, producers expect that polypropylene growth eventually will slow down. But at least one has said that it has already had to upgrade estimates for 1987 and 1988, because earlier forecasts were too conservative. Most companies have been predicting that growth in demand for polypropylene in industrial regions such as North America, Western Europe, and Japan will be slower than in the rest of the world, probably 4 to 5% per year, compared with 6 to 7% in the rest of the world. However, consumption actually grew throughout 1987 at a 14 to 15% clip.

Some analysts worry about basing plans for new capacity expansions on such growth rates, even the conservative forecasts. Says Morgan Stanley analyst Stuart Wamsley: "Although those companies that are moving ahead with investment in major new ... polypropylene ... plants may well reap considerable rewards if the world's economies continue to expand, there will be some very red faces, seriously depleted profit and loss accounts, and damaged balance sheets if a downturn does materialize." Much wiser, he argues, is a modest course of debottlenecking, or allowing capacity to creep up gradually.

On the other hand, other industry observers feel that the situation won't be that bad for polypropylene. Tony Church, chemicals specialist with analysts Wertheim Schroder & Co., concedes that "there is undoubtedly a concentration of new plants in late 1989," but he thinks that the scrapping of old facilities and delays in the startups of new plants will alleviate the impact of "bunching" new plants.

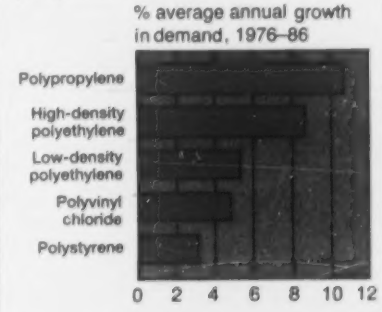
Moreover, demand for polypropylene on a global basis is growing faster than available supply, he points out. "An economic slowdown in late 1988 and new plants starting up in 1989 could put an end to the current tightness of supply, but we see no signs of a major slowdown for at least nine to 12 months. On a longer-term basis, our forecasts suggest that the current industry capacity increase is not excessive."

By and large, if growth matches the predicted rates, any overcapacity that develops from 1990 to 1992 will be short-lived, relatively painlessly absorbed by the markets. However, the future global economy worries some more conservative producers; they fret over the possibility of slowed growth and outright recession.

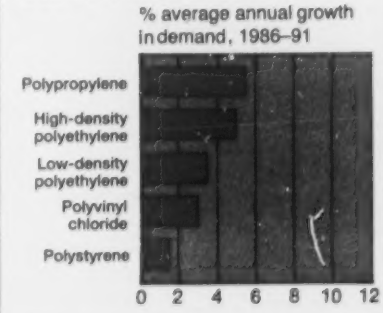
Given the gamesmanship of the business, it's difficult to predict how the industry might weather some of the possibilities. For instance, at least some of the announced planned capacity probably will never be built. In many respects it is like a poker game: If one company announces a large enough new plant, will that spook others into pulling back on their plans? Or can one company negotiate more favorable contracts from other suppliers in return for not building additional capacity? For example, Belgian carpetmaker Beaulieu has announced that it will build a 120,000 metric ton-per-year polypropylene plant in Dunkirk, France, to start up in 1989 to ensure its supply of polypropylene fiber for carpetbacking. Industry observers were not convinced that Beaulieu actually would build its plant—it might have been a bid to help it with favorable long-term contracts for its supply. However, Beaulieu in December took a license from Union Carbide to build its plant, so its plan is definite.

Alternatively, a producer might ask, if it makes dire-enough predictions, whether that will convince others not to plan expansions. At least one producer, following expansion announcements from its competitors, has said, "In the field of polypropylene, the lemmings are already gathering, and some are looking over the cliff. If you add up all the information, you can get afraid of what is going to happen." That may be true, but then again, that producer also plans significant expansions.

Polypropylene tops other polymers in growth...



. . . and will continue to, but at a slower rate



Source: Hoechst A.G.

Four companies account for a fourth of worldwide capacity

Thousands of metric tons	Nameplate capacity in 1988[a]	Planned expansions to 1995
Himont (U.S.)[b]	1800	150
Shell (U.K./Netherlands)	875	120
Amoco (U.S.)	570	
Hoechst (West Germany)	515	110
25% of total world capacity in 1988[b]		
Exxon (U.S.)	430	70
Fina (U.S.)	380	
ICI (U.K.)	300	100
Appryl (France)	265	
Neste (Finland)	240	200
DeMV (Austria)	200	120
50% of world capacity		
Phillips (U.S.)	190	
El Paso (U.S.)	165	135
Soltex (U.S.)	135	95
BASF (West Germany)	135	150
Solvay (Belgium)	130	
DSM (Netherlands)	120	
Huels (West Germany)	120	
Montefina (Italy)	120	
60% of world capacity		

Note: All locations indicate headquarters, not necessarily plant sites. **a** Design capacity based on announcements through December 1987, with no allowances made for scrapping of old capacity unless companies have announced specific plans to scrap. **b** 11.1 million metric tons. **Source:** Wertheim Schroder & Co., London

One of the natural limits to any polypropylene expansion will be feedstock availability, a point virtually all producers and analysts agree on. Increasingly, they predict, if a producer has no internal or well-tied source of propylene, it will be difficult to expand polypropylene production, or perhaps even keep up present levels. For example, a world-scale plant is now considered 120,000 metric tons per year. "You wouldn't do an expansion unless it was that amount, and to contract for that much propylene will be difficult to do," says one supplier. "If you are not integrated into propylene, it will get more and more difficult."

Propylene supply is not a foolproof limit, however. For example, some of the projects under way or under consideration will depend on dehydrogenation of propane. Saudi Basic Industries Corp. (SABIC), for one, is currently conducting feasibility studies on polypropylene to be completed later this year. Although the company declines to comment before the studies are completed, it is examining plans for a joint venture, probably with Neste of Finland, to produce 200,000 to 250,000 metric tons of propylene, with either a portion or all converted into polypropylene. The propylene production would come through propane dehydrogenation.

Some suppliers feel that SABIC is waiting to see what happens with a new polypropylene project under way in Thailand—one of the first of its kind. Dehydrogenation propylene will feed a 100,000 metric ton-per-year polypropylene plant. Points out one supplier, "No one really has any commercial experience with this technology yet. Everyone is waiting to see what happens."

But clearly, the idea of propane dehydrogenation has attractions. The recently announced joint venture between Himont and Statoil of Norway for a polypropylene plant in Belgium has as one option feedstocks of dehydrogenation propylene—a fully integrated facility, starting with propane, going through dehydrogenation to propylene, and on to polypropylene. In this case, the joint venture was particularly well suited for Himont, with no secure source of feedstock for a new plant in Europe. And it helps move the company away from the industry's historical dependence on feedstock supply from ethylene crackers or refineries. The linkup also suits Statoil, which will have abundant quantities of propane from its North Sea operations via a refinery in Norway, which is due on stream by 1990.

The other limit to overcapacity in the industry will be the relative abundance of old-technology plants. These can continue to be run profitably when the market is tight and selling prices high. But if there is significant overcapacity, and prices and margins begin slipping, older, more expensive technology is more and more costly to operate. Hence, those conditions might provide an incentive for companies who had procrastinated in scrapping to finally do so.

According to one industry source, an analysis of aging polypropylene capacity would suggest that at least 50% of production is in plants more than 10 years old. "In a technology moving as rapidly as polypropylene, a 10-year-old plant is no longer competitive, either economically or technologically," he contends. "These plants are viable now only because of the tight market, but they are the marginal plants. We expect something similar to what happened as linear low-density polyethylene has come in: Old-plant producers will drop out."

Perhaps even more than with polyethylene, polypropylene producers have been reluctant in the past to commit to new plants because of the continuing debate over technology. Says one supplier, "There has been a technological revolution, and those wanting to expand have been very careful to stay on the knife edge of technology."

"Before 1983 was a very bad time for polypropylene," another supplier says. "Since about 1982, capacity utilization has improved from about 65%. But when people saw capacity utilization coming up, they didn't have the confidence to expand. It has been drummed into our heads that there are five-year cycles, and we didn't want to go crazy. The world never stopped building polypropylene plants, but we didn't have the confidence to build them fast enough." Nor did people expect growth rates to continue as strongly as they have, this supplier adds.

"We all were asking, how much of that was real growth? How much was pipeline filling? How much was substitution? But when the growth lasts this long," one marketer argues, "it has reached a steady state. It is not just pipeline filling, but true growth in demand. And in any growing demand, you must have a growth in stock."

Who will be growing, then? The majors—the top two, Himont and Shell certainly, and the next level, as serious contenders. But with world scale at 120,000 metric tons per year, a number of producers now are almost in what one producer terms a "double or quit situation—they are playing games now." □